THE MOUNT THIRSTY PROCESS

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1. INTRODUCTION

1.1. MT THIRSTY PROJECT SUMMARY

The Mount Thristy Project is based on an oxide cobalt and nickel deposit located approximately 20 km north-west of Norseman in Western Australia. The deposit is owned 50% each by Barra Resources Ltd and Fission Energy Ltd. It is currently in the Pre-Feasibility Study stage of development with first production slated for 2015.

Presently delineated resources stand at an estimated combined Indicated and Inferred Resource of 29,030,000 tonnes grading 0.12% Cobalt, 0.56% Nickel and 0.88% Manganese, with further upside possible from extensional drilling.

The Mt Thirsty Project has the potential to be become a very significant cobalt producer with annual production of approximately 4,000 tonnes of cobalt and 10,000 tonnes of nickel contained within a mixed sulphide intermediate product. In addition up to 13,000 tonnes of contained manganese will be produced as a high purity manganese carbonate product. Metallurgical testwork indicates that high extractions of cobalt, nickel and manganese are possible from ore using atmospheric sulphuric acid leaching.

A novel method for leaching the ore at atmospheric conditions was developed specifically for the Mt Thirsty ore body which has some unusual mineralogy compared to typical laterite deposits. Conditions are controlled within the leaching process to reduce manganese minerals contained within the ore while allowing leached impurities such as iron to precipitate as sodium jarosite during the leaching stage. Jarsoite precipitation allows removal of a major impurity from solution in a form which is easy to settle and regenerates acid.

Downstream processing consists of separating the leach residue solids from the pregnant leach solution in a conventional counter current decantation circuit. The very good solid-liquid separation properties of the leach residues produced allow for low flocculant consumption and high underflow densities.

Cobalt and nickel are recovered from the pregnant leach solution via precpitation with sodium sulphide. This results in the formation of a high grade and high purity mixed sulphide product containing approximately 10% cobalt and 44% nickel. The barren solution from the mixed sulphide precipitation is then treated in a secondary neutralisation circuit to precipitate impurities such as iron and aluminium prior to the manganese recovery circuit. Manganese is recovered from solution by precipitation with soda ash to yield a high purity carbonate product.

It is planned to export the Cobalt-Nickel Mixed Sulphide and Manganese Carbonate intermediate products produced for sale to third parties for refining. During 2010 The Mount Thirsty Joint Venture (MTJV) will be completing a Pre-Feasibilty Study to further define all aspects of the project, in readiness for a Definitive Feasibility Study planned for 2011.

1.2. THE MOUNT THIRSTY PROJECT GEOLOGY

The Mount Thristy deposit is an oxide cobalt and nickel deposit located approximately 20 km North West of Norseman in Western Australia. The deposit was discovered in 1998 by Resolute Ltd during the development of the Bulong Project, as additional sources of cobalt were required. A 50% stake in the project was aquired by Barra Resources in December 2006.

In December 2006, when Barra Resources farmed into the project the known indicated and inferred resources delineated in the deposit were:

8.4 Million tonnes grading 0.65% nickel and 0.20% cobalt.

Geological development work was performed by Barra Resources in 2007 and 2008, which resulted in a substantial increase in the resource base. In mid 2008 Fission Energy purchase a 100% interest in Meteroe Metals Ltd the holder of the other 50% of the Mt Thirsty Deposit. In June 2008 the following JORC consistent resources were announced for the Mt Thirsty deposit by the Mount Thirsty Joint Venture (MTJV):

These were estimate by Independent mining and geological consulting firm Golder Associates Pty Ltd using a cut-off grade application of 0.06% Co.

Category	Million Tonnes	Co %	Ni %	Mn %	Fe %	Mg %
Indicated Resources	14.80	0.14	0.59	0.99	25.14	2.64
Inferred Resources	14.23	0.11	0.52	0.77	19.45	3.54
Total Resources	29.03	0.12	0.56	0.88	22.35	3.06

Table 1. Mt Thirsty Deposit Resources

The total Indicated and Inferred Resource contains approximately 162,000 tonnes of nickel, 35,000 tonnes of cobalt and 255,000 tonnes of manganese. Drilling that has been completed to the north of the known resources indicates a continuation of the orebody. These are not yet included in the total Mt Thirsty Project resources

The deposit is hosted in ultramafic periodotite orthocumulate rocks located between basalt to the west and pyroxenite to the east. The supergene enrichment process at Mt Thirsty has produced an oxide deposit which is enriched in cobalt, nickel and manganese. The manganese and cobalt content is particularly high compared to most nickel laterite deposits located in Western Australia. The following Figure 1 details the location of the deposit geologically.

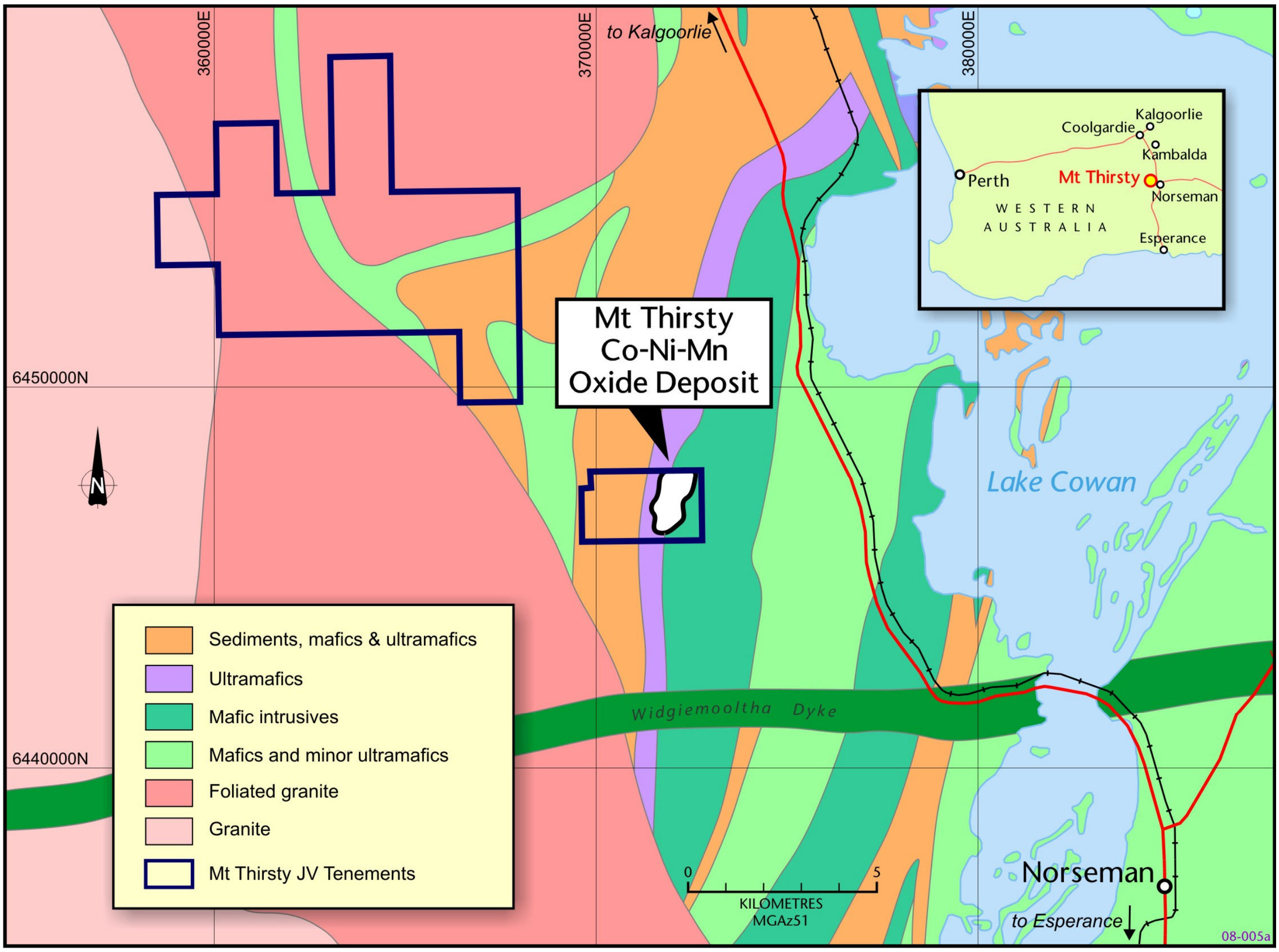

Figure 1. Mt Thirsty Local Area Geology

Three main weathering zones are commonly encounted within the ore body. The mineralised area typically starts at 10 meters below the surface where limonitic clays are present with an iron composition of around 30%. As the mineralisation deepens the colour of the limonitic clays darkens as the content of asbolane increases in the ore. This darkening of the limonitic clays marks the start of the high grade portion of the deposit and likely ore source. The colour of the limonite changes to patches of near black fine asbolane mixed with limonite and speckled with kaolinite. Deeper down, the dark colouring of the asbolane starts to recede with nontronite and serpentine minerals becoming dominant. Near the bottom of the saprolie zone chalcedony banding is commonly encounted. This marks the end of the economic ore zone, as high grade cobalt and nickel are almost always associated with dark asbolane. Figure 2 shows an example of a typical ore profile.

The moisture content of the deposit is low, with an average free moisture content of 4%. The water table is located below the mineralised zone, so no mine de-watering is expected during mining. Preliminary mining assessment also show the deposit will be free digging with favourable geotechnical properties apparent. The low moisture content also results in a high in-situ bulk density of the ore with an average specific gravity of 1.8 observed for the deposit. The high bulk density in combination with the relatively large ore thickness results in a large tonnage density per unit area.

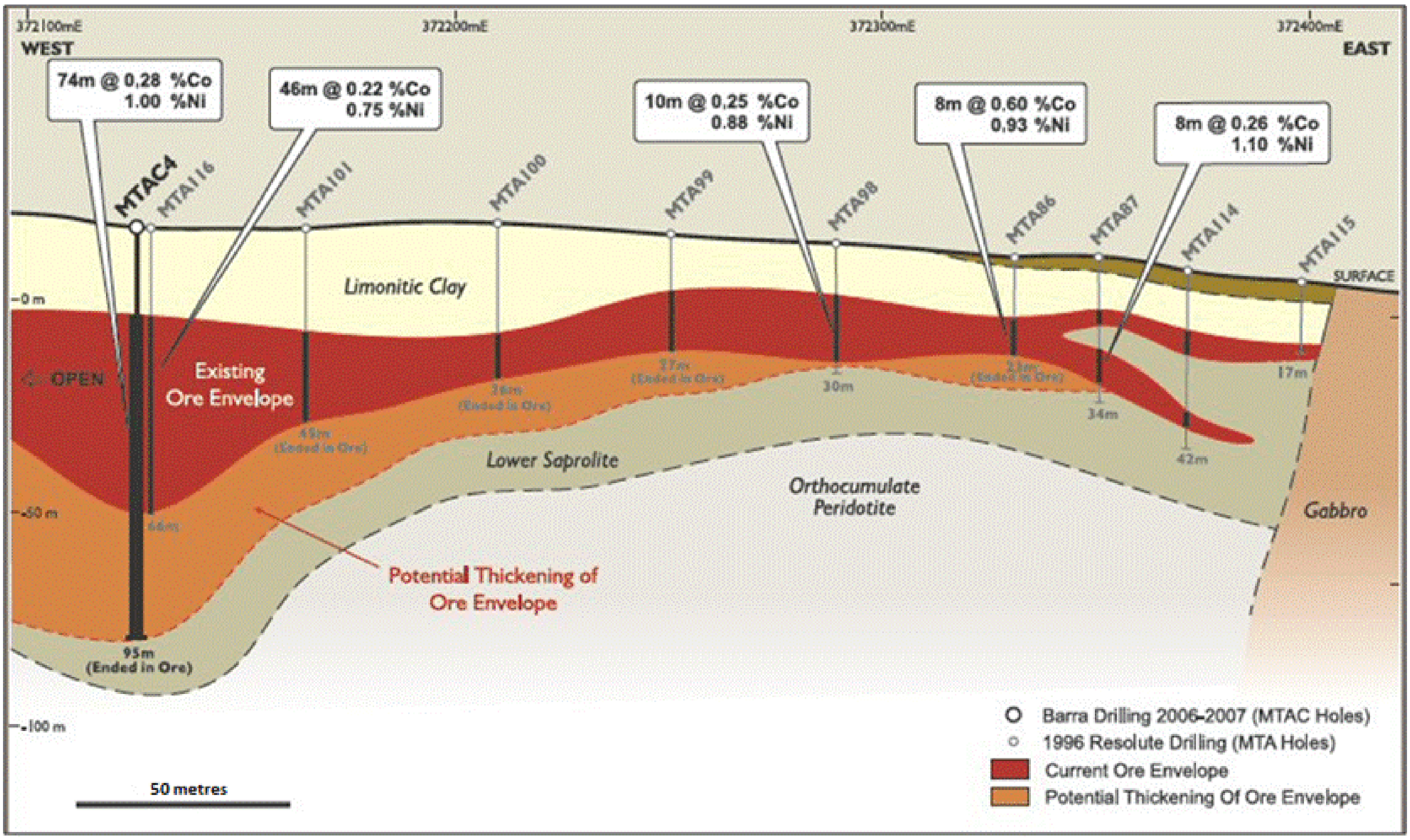

Figure 2. Mt Thirsty Typical Ore Profile

1.3. MOUNT THIRSTY LOCATION AND INFRASTRUCTURE

The location of the Mt Thirsty deposit is depicted in Figure 3 below:

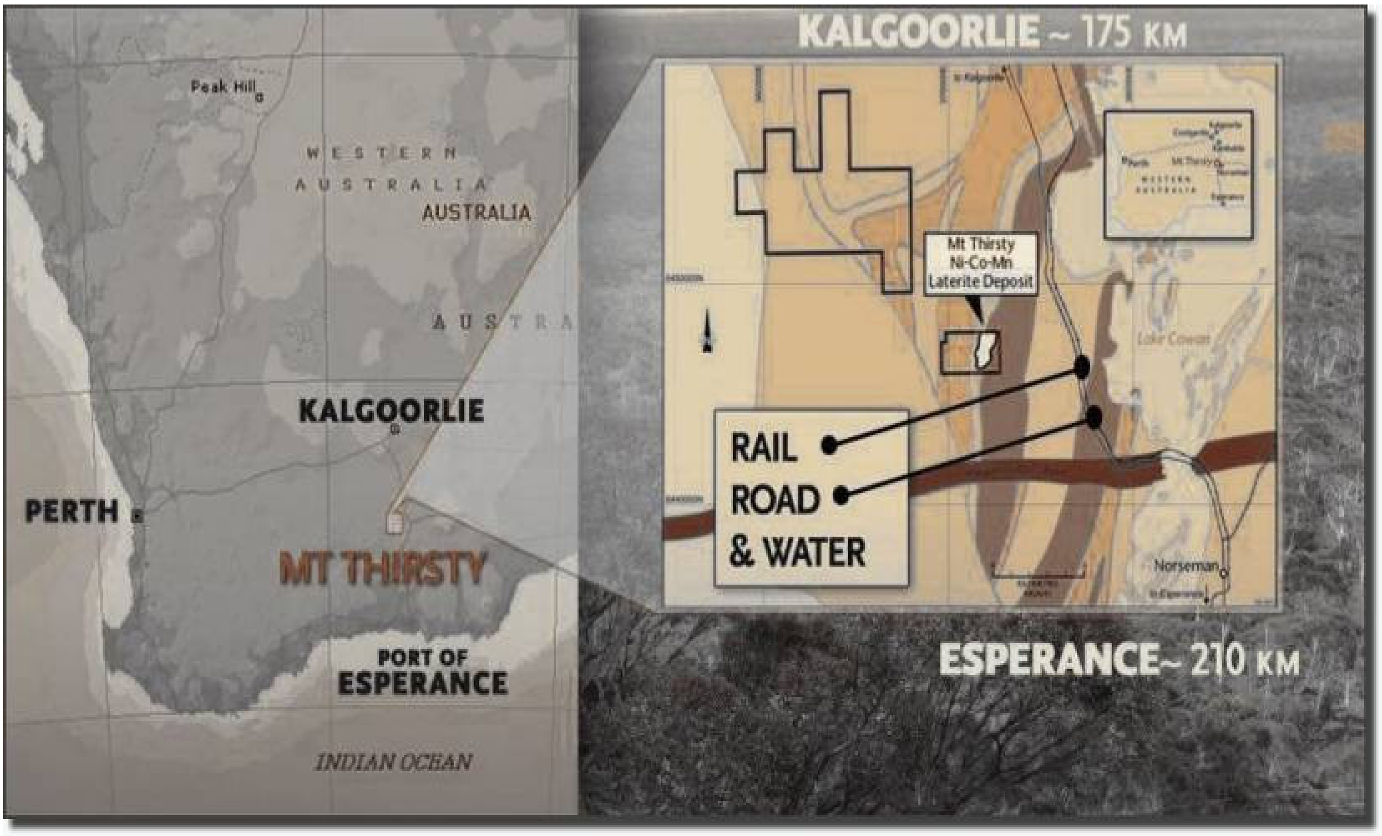

Figure 3. Location of the Mt Thirsty Deposit

Access to the deposit is via an unpaved 4 km road from the Kambalda-Norseman highway. Running adjacent to the highway is the Goldfields-Esperance gas pipeline, railway line from Esperance to the Goldfields and the Kalgoorlie-Norseman water pipeline. All of which are in close and convienient proximity to potential plant site locations.

The railway line can be directly connected to the Port Of Esperance which allows near full rail transport from the port to the plant site.

Limestone is available from a number of local sources including a hard calcrete deposit approximately 50 kilometers north west of the deposit and a limesand quarry located near Esperance. The limesand quarry is presntly in operation, supplying high quality limesand to the local agricultural industry.

Located approximately 25 km by road is the Town of Norseman which is currently host to a population of approximately 850. The main industry in Norseman is mining, local gold and gypsum mines currently in operation. Previously Norseman's population was stable at greater than 4,000 permanent citizens with many facilities remaining from this time. The social infrastructure in the town appears to be adequate for supporting a significant increase in the town's population associated with the commencement of construction and mining operations at Mt Thirsty. It is the intention of the owners of the Mt Thirsty project to support regional Western Australia by offering residential based employment at the mine in addition to a Fly in/Fly out option. This would result in a signficant increase in company supplied housing and investment in the Town of Norseman.

1.4. PROCESS DEVELOPMENT STUDY

The MTJV engaged Independent Metallurgical Operations Pty Ltd (IMO) to undertake a process development study for the project. This broadly entailed devising a shortlist of suitable flowsheets and managing a laboratory testwork program to confirm the metallurgical performance. Due to the location of the deposit and the size of the resource it was considered prudent to pursue the production of intermediate products rather than final metal products. This effectively moves the refining part of the process to an established refiner of nickel and cobalt products. The following criteria were therefore applied to the process selection:

1. Production of intermediate products with existing markets;
2. Simple flowsheet with limited number of processing steps to improve ramp up;
3. Use standard processing equipment, in particular no high pressure acid leaching autoclaves, to maximise plant availability;
4. Utilise the characteristics of the ore body and local resources.

With the above in mind, atmospheric leaching flowsheets were investigated to determine how to effectively leach value metals from the ore. This would form a major part of the metallurgical testwork performed.

The technical focus of this paper is the laboratory testwork which contributed to the development of the Mt Thristy Leaching Process. Laboratory batch testwork was performed on all major steps of the expected commercial process. For the major process steps which are sensitive to mineralogy and geochemistry, actual Mt Thirsty ore was utilized. For downstream solution processing, synthetic solutions were used to optimize the plant conditions required to remove impurities and produce satisfactory products. A final flowsheet run was performed to batch test a large sample of ore with real solution through each stage of the process.

2. MT THIRSTY PROCESS DEVELOPMENT PROGRAM

2.1. SAMPLE SELECTION

2.1.1. Ore Sample

Metallurgical samples for the process development study were selected to provide a composite sample which was close to the resource average of mine grade material within the deposit. The bulk of the metallurgical developmetn work would be performed on this sample. Once the process parameters where better defined, it was planned to examine the metallurgical response across a range of smaller samples.

Geological modelling provided information on two main ore types within the depost. These are the high iron ore (greater than 20% Fe) and the low iron ore (less than 20% Fe).

The expected average chemical composition for a combined ore feed to a processing plant is shown in the following Table 2.

Chemical Composition (%)						
Co	**Ni**	**Mn**	**Fe**	**Al**	**Mg**	**Si**
0.13	**0.65**	**0.93**	**22.4**	**4.2**	**3.9**	**18.3**

Table 2. Expected average chemical composition of process plant feed

Samples to provide blending material where sourced from a combination of previous test pitting and air core resource drilling. Actual samples from air core resource drilling were selected to provide a spread across the deposit while mainly targeting the low iron ore.

The samples were appropriately sub-sampled to maximise representivity and composited to match as closely as possible to the resource averages. Table 3 shows the composition of the composites produced compared to the resource average.

	Ni	Co	Mg	Fe	Mn
Low Iron Feed Assays (%)					
Target	0.52	0.10	4.0	17.0	0.71
Actual	0.60	0.13	4.9	16.5	1.02
High Iron Feed Assays (%)					
Target	0.59	0.13	2.5	26.4	0.97
Actual	0.68	0.14	3.0	26.3	1.0
Resource Average Feed Assays (%)					
Target	0.56	0.12	3.2	22.1	0.85
Actual	0.65	0.13	3.9	22.4	0.93

Table 3. Comparison of Composite Sample Assay to Resource Average Grade

2.1.2. Limesand

In addition to ore samples, local water and limesand were also prepared. The limesand sample was taken from an active quarry located to the west of Esperance. The quarry currently supplies approximately 60,000 tonnes per annum of limesand to the local agricultural industry. The chemical analysis of this sample is presented below in Table 4.

Assay (%)						
Ca	Mg	CO_3	Si	Al	Fe	S
24.8	1.82	44.5	12.4	0.80	0.21	0.59

Table 4. Esperance Limesand Chemical Analysis.

2.1.3. Process Water

The site water available near the deposit is known to be of variable salinity. No data is available on water quality in the Mount Thirsty area. However, after discussions with a water consultant, with experience in the area, a salinity level of twice sea water was selected for the testwork program. The solution was prepared by dissolving technical grade NaCl and $MgSO_4.7H_2O$ in Perth tap water to achieve 21 g/L Na and 2.5 g/L Mg.

2.2. MINERALOGY

Previous mineralogical analysis was reviewed to provide insights as to the best treatment method for the ore. In addition, the deportment of value metals within the minerals is important for determining the effective methods of treatment. The following is a summary of the mineralogy of the Mt Thirsty ore:

Major Minerals Present

Goethite – Iron oxide fine mineral - Contains approximately half of the nickel in the ore
Serpentine – Magnesium silicate with friable texture - Contains approximately one quarter of the nickel in the ore

Kaolinite – Aluminium clay containing no value metals

Minor

Asbolane – Manganese Dioxide – Contains almost all the manganese and cobalt and approximately one of quarter of the nickel. Nickel and cobalt complex hydroxides are known to adsorb on the surface of grains of Asbolane.
Chalcedony – Coarse silica – Contains no value metals and is effectively inert in mild leaching conditions.
Nontronite – Iron 2:1 Clay mineral in which contains some nickel substitution for iron with the clay layers.

Rare

Chromite – The deposit is low in chromium
Haematite – Iron Oxide

The mineralogy of the deposit reveals a high degree of oxidation which has implications for processing. In particular the vast majority of the cobalt resides within one mineral while the nickel is contained within a variety of mineral types.

2.3. ORE PREPARATION TESTWORK

Scrubbing or clay dispersion testwork was conducted on each of the prepared composite samples of high iron and low iron ore. A laboratory scale rotary drum was used to perform batch scrubbing tests to examine parameters and observe the product particle size distribution. An ore charge of 60 kg was used with hypersaline water added to provide a scrubbing density of 55% solids.

The scrubber products were taken for size by size chemical analysis with the results presented in Figures 4 and 5.

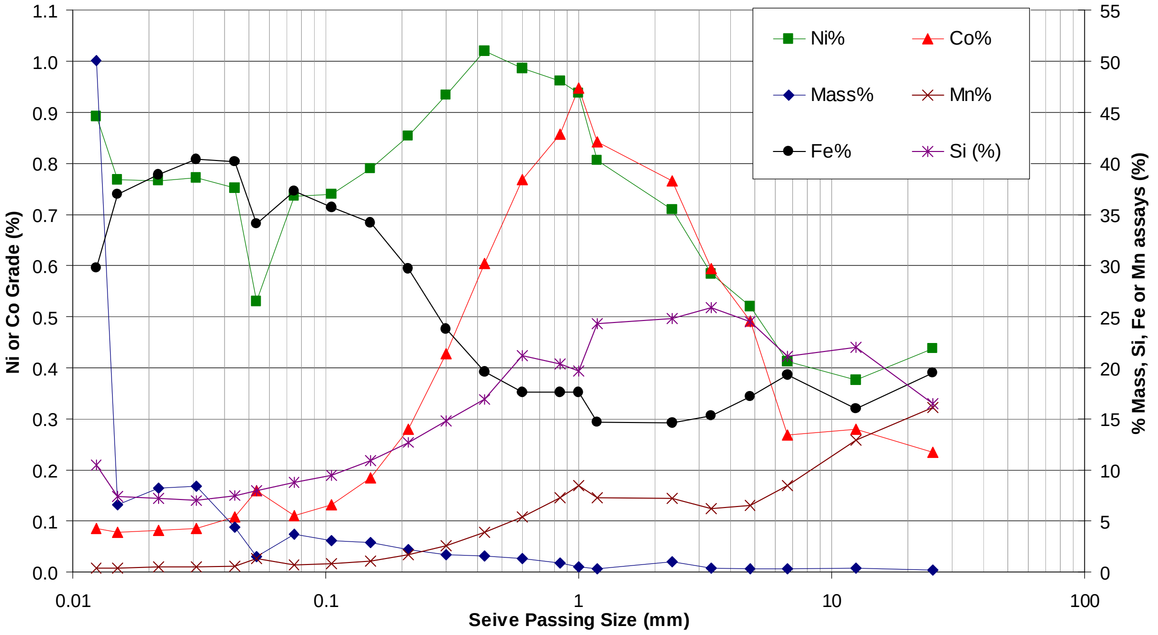

Figure 4. Scrubbed High Iron Ore Type Size By Assay Results

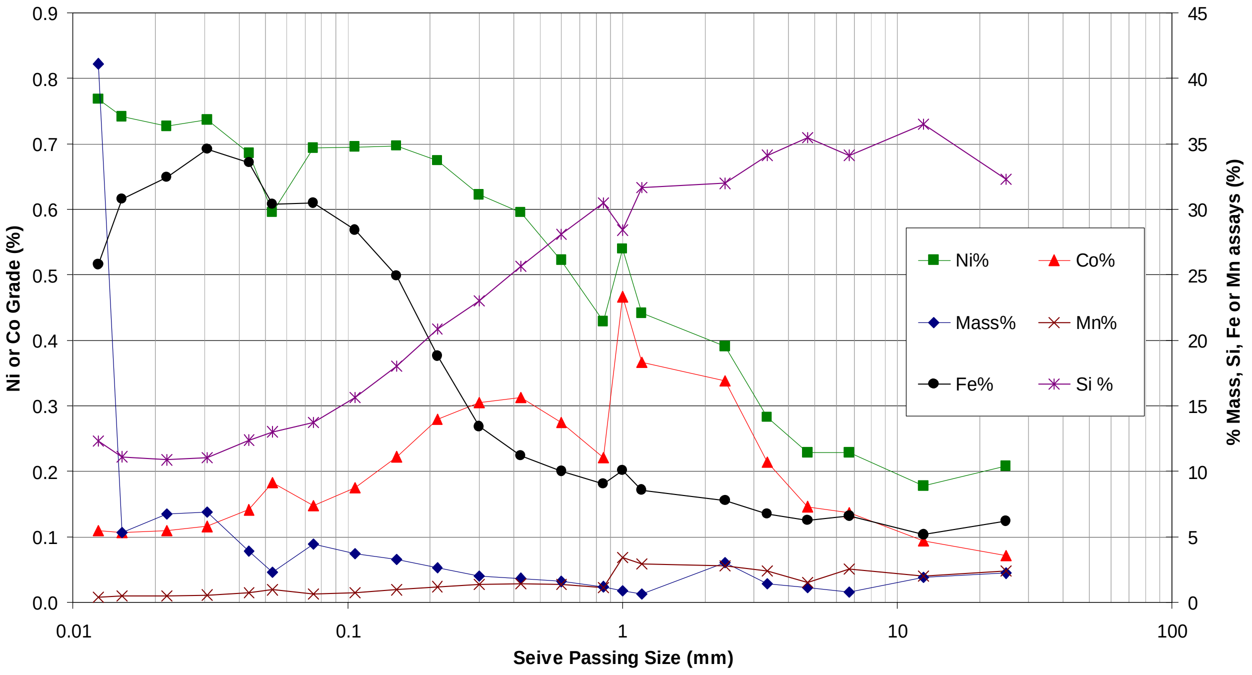

Figure 5. Scrubbed Low Iron Ore Type Size By Assay Results

Analysis of the ore preparation results reveals the following:

- The majority of the ore is fine with the vast majority of the mass passing 75 microns while a minor amount was >1 mm.
- Nickel and iron are concentrated in the finer fraction. This is consistent with nickel being hosted in an iron mineral, probably goethite.
- Manganese and to a lesser extent cobalt, concentrate in the coarser fraction. There is a strong correlation between cobalt and manganese grades in the -1mm fractions. At the coarser sizes the manganese tenors remain relatively flat while cobalt tenors decrease.
- Silicon tenors steadily increased with increasing particle size attaining 35% Si in the +4 mm fraction.
- There is no obvious size fraction which could be rejected without discarding significant values of targeted product material. Potentially coarse rocky fractions could be discarded however they make up a low proportion of the overall feed.

2.4. PARAMETRIC LEACHING TESTS

In order to determine the most suitable atmospheric leaching conditions a range of key parameters were investigated individually to determine their sensitivity on leach performance. Based on previous experience the following parameters are known to have an impact on sulphuric acid leaching of nickel laterite ore:

- Acid concentration in solution or acid dose
- Leaching temperature
- Oxidation-Reduction Potential to be controlled by sulphur dioxide dose

A series of laboratory bench scale tests were performed with the slurry density maintained at 40% solids and a residence time of 5 hours allowed. All of the tests used the combined resource average ore composite sample slurried in hypersaline water.

2.4.1. Effect Of Temperature

A series of tests were completed at 60°C, 75°C, 85°C and 95°C. The SO_2 gas and sulphuric acid additions were kept constant at 75 mL/min and 300 kg/t respectively. Figure 6 summarises the results of the temperature investigation.

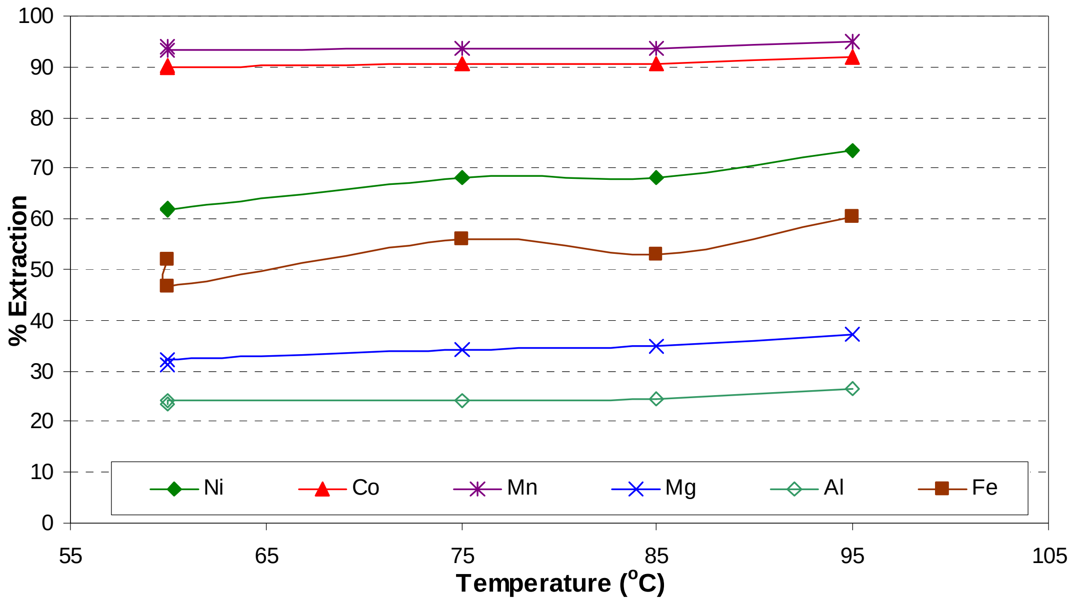

Figure 6. Impact Of Tempature On Parametric Leach Performance

The results reveal cobalt and manganese dissolution is insensitive to temperature which implies the asbolane mineral is readily leached under these conditions. Kinetic testing showed the cobalt and manganese reached greater than 90% extraction in approximately 2 hours while nickel continued to leach until the termination of the test at 5 hours. Iron extraction and to a lesser extent aluminium extraction follow that of the nickel.

2.4.2. Effect of Acid Dose

A series of tests were completed at an acid dose of 0 , 100, 200, 300 and 500 kg acid per tonne of dry solids. The SO_2 gas addition and temperature were kept constant at 75 mL/min and 95^oC respectively. Figure 7 summarises the results of the acid dose investigation.

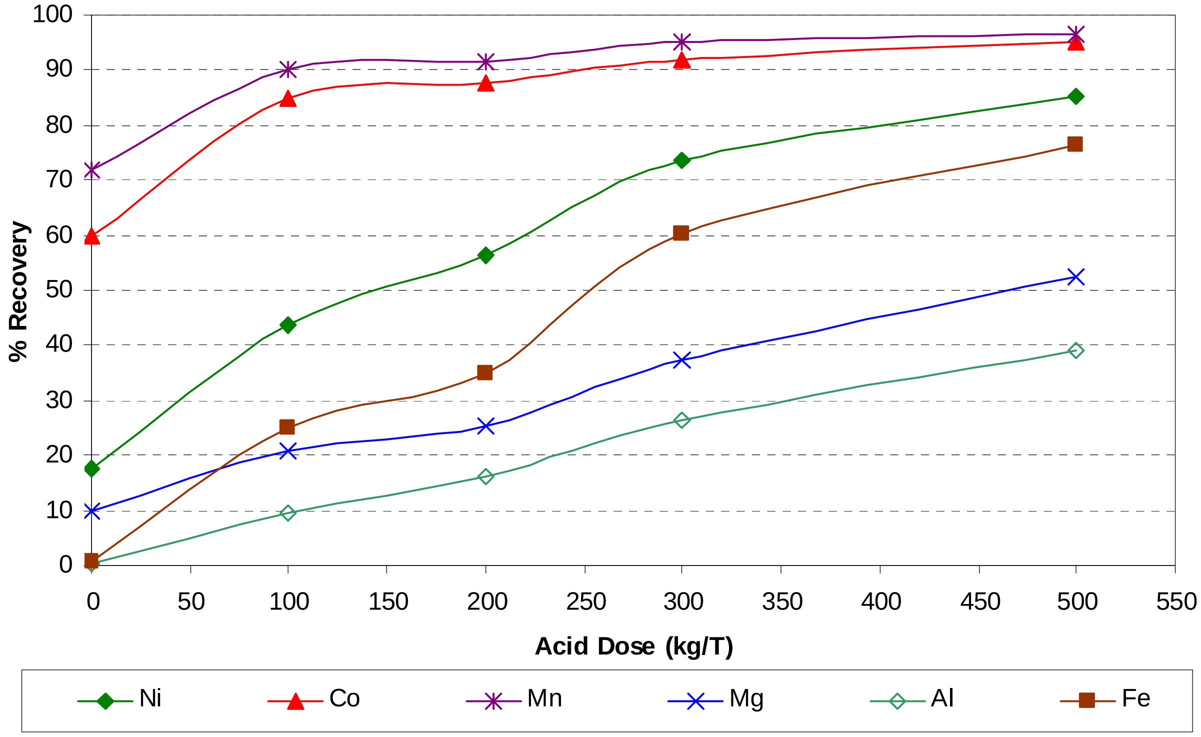

Figure 7. Impact Of Acid Dose On Metal Extractions From Ore

Acid dose had a very signficant affect on leaching, with the extraction of all metals increasing with acid dose. Cobalt and manganese reached near complete extraction at lower acid consumption levels than other metals. Nickel and other impurities continued to leach into solution as the acid dose increased. Considerable acid consumption is required for nickel to achieve similar extraction to that of cobalt. However, with increased nickel extraction there is also increased extraction of impurities such as iron, aluminium and magnesium.

2.4.3. Effect of Sulphur Dioxde Dose

A series of tests were completed at a sulphur dioxide dose of 9, 11, 75 and 150 ml/min. The acid addition and temperature were kept constant at 300 kg/tonne and 95°C respectively. The following Figure 8 summarises the results of the sulphur dioxide dose investigation.

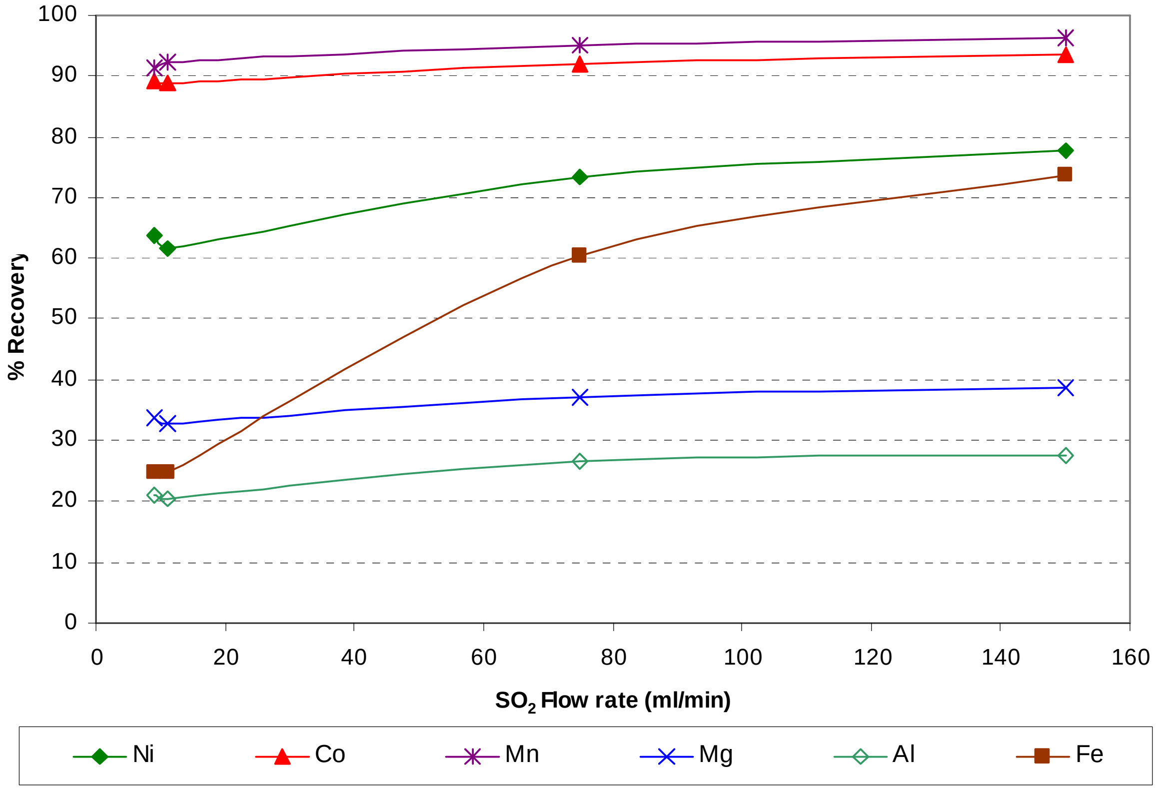

Figure 8. Impact Of SO_2 Dose On Metal Extraction

The extraction of all metals increased with increasing sulphur dioxide dose or more reducing conditions. Iron extraction to solution was most strongly impacted by the increased reducing conditions. This can be attributed to the changing iron valency with changing sulphur dioxide dose. At lower sulphur dioxide dosages (or less reducing conditions) the iron is present mainly in the ferric state (Fe (III)) which tends to precipitate as jarosite in the presence of excess sodium irons in solution. At higher sulphur dioxide dosages the iron is mainly in the ferrous state which does not precipitate as jarosite.

Jarosite precipitation is slow and the five hour leach residence time used in these tests is not sufficient for the jarosite precipitation to approach equilibrium. If a longer residence time was employed, then iron precipitation would be more complete, leading to lower iron tenors in solution.

2.5. SPLIT LEACHING TESTWORK

A split atmospheric leaching process uses the high iron and low iron ore types separately to optimise leaching performance. The higher iron portion of the deposit requires short residence times to leach cobalt and manganese from the ore and put a considerable amount of iron into solution. The following reactions are typical of the high iron leach:

$$(Fe,Ni)OOH + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2O + NiSO_4 \quad (1)$$

$$MnO(OH)_2 + SO_2 \rightarrow MnSO_4 + H_2O \quad (2)$$

$6Fe(OH)_3 + 3SO_2 + 3H_2SO_4 \rightarrow 6FeSO_4 + 12 H_2O$ (3)

The residual acid following the high iron leach (primary leach) is neutralised via the addition of low iron ore which both neutralises acid and oxidises Iron(II) in solution. In doing so, a high concentration of Iron(III) is produced in solution, which reacts with sodium ions from the hypersaline process water, to form sodium jarosite according to the following reactions.

$H_2SO_4 + (Mg,Ni)\ {}_2Si_2O_5(OH)_4 \rightarrow MgSO_4 + NiSO_4 + SiO_2$ (4)

$6Fe(OH)_3 + 2NaCl + 4H_2SO_4 \rightarrow 2NaFe_3(SO_4)_2(OH)_6 + 2HCl + 6H_2O$ (5)

$2Fe_2(SO_4)_3 + 12H_2O + 2NaCl \rightarrow 2NaFe_3(SO_4)_2(OH)_6 + 2HCl + 5H_2SO_4$ (6)

The precipitation of iron as sodium jarosite both removes it as an impurity from solution and regenerates acid which is then available to leach additional nickel bearing ore.

A range of split leach tests were performed to investigate the effect of temperature and acid dose on the extaction of value metals and impurities. Separate high iron and low iron slurries were prepared in hypersaline water to provide feedstock for each of the split leach tests.

2.5.1. Effect of Acid Dose On Split Leaching

A series of tests were performed with acid doses ranging from 175 to 513 kg of acid per tonne of ore solids. Figure 9 summarises the results.

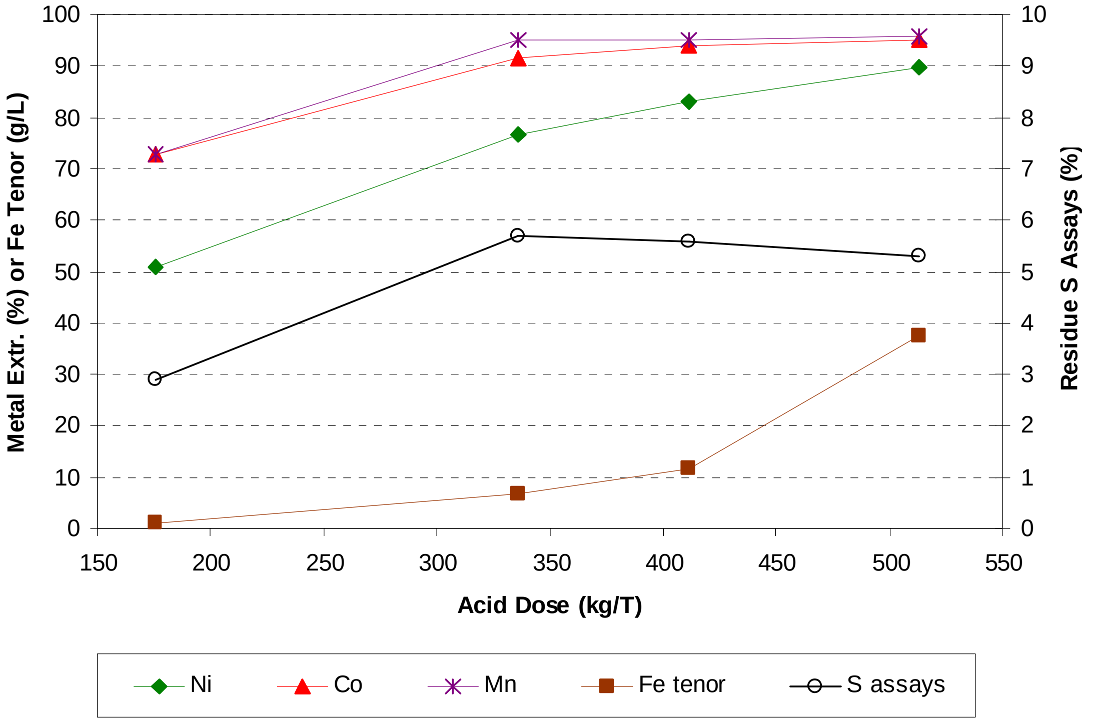

Figure 9. Impact of Acid Dose On Split Leach Performance

The results show the following:

- Nickel extractions increased with increasing acid dose, attaining 90% at 513 kg/t acid addition;
- Cobalt recoveries showed a slight increase from 91% to 95% as acid dose increased from ≈340 kg/t to 513 kg/t, while manganese recoveries remained relatively flat over this acid range. Of note the flattening cobalt extraction at approximately 340 kg acid/tonne of ore may indicate a key economic acid addition point.
- Iron tenors in solution remained relatively low up to 413 kg/t acid, while the residue sulphur grade increased, indicating efficient jarosite precipitation. As the acid dose increased to 513 kg/t, iron tenors in solution increased sharply while the suphur tenor of the residues decreased slightly and indicates that significant jarosite precipitation is still achieved but is

starting to be inhibited by the increasing free acid tenors in solution. A free acid tenor of 30 g/L or less results in efficient jarosite precipitation

- Magnesium and aluminium dissolution increased linearly with acid dose.

2.5.2. Effect of Temperature On Split Leach

Four tests were completed to identify the impact of temperature in the first and second stages of the leach. The acid dose varied slightly ranging from 306 kg/t to 336 kg/t. The results are summarized in the table below.

Leach	Temperature (^oC)		Acid Dose	Metal Recovery (%)			Liquor Tenors (g/L)		
ID	Stage 1	Stage 2	Kg/t	Ni	Co	Mn	Fe	Fe(II)	Al
JA 1225	68	95	306	78	91	94	6	1	8.9
MU 141	95	70	308	65	89	94	56	6	12.5
MU 140	95	95	310	76	91	95	11	4	9.1
SB 1160	95	95	336	77	92	95	7	2	9.5

Table 5. Impact of Temperature On Split Leach Performance

The results show that ultimate metal recovery was not impacted by reducing the first stage leach temperature from 95^oC (MU 140) to 68^oC (JA 1225). Metal recovery at the end of the first stage leach was lower at 68^oC (68% Ni recovery) compared to 82% Ni recovery for the first stage leach at 95^oC. However when the temperature was increased in the second stage, the overall nickel recovery was the same for both systems. The results indicate that the leach is robust with respect to the temperature of the first leach stage. Leach recovery was significantly reduced when the second stage leach temperature was reduced from 95^oC to 70^oC, as was iron rejection, as jarosite precipitation was inhibited.

2.6. SINGLE STAGE LEACHING

The concept of leaching the entire ore profile in a single stage leach was investigated as it offered a number of advantages over the split leaching process. It eliminates the need to prepare two separate feed slurries and simplifies mining operations. The single stage atmospheric leaching process aims to control conditions which allow high metal recoveries while still precipitating iron as jarosite during the leaching process. A range of leaching parameters were investigated to determine if this was possible. Leach conditions were controlled at:

Solids density	40% w/w
SO_2 flowrate	controlled to target Fe(II) in solution
Temperature	95^oC
Residence time	24 hrs
Acid dose	300, 400, 500 kg/t

Jarosite seed was prepared for each of the tests, to simulate continuous conditions as jarosite precipitation induction time had been shown to impact on earlier work.

2.6.1. Effect of Sulphur Dioxide Dose on Single Stage Leach

The effect of Fe(II) concentration (SO_2 dose) on leach performance was determined at 300 kg/t acid. The results are summarised in Table 6.

Test	% Rec			Liquor Tenors (g/L)		
ID	Ni	Co	Mn	Al	Fe	Fe(II)
SB 1204	75	91	94	7.7	3.4	0.7
SB 1207	72	91	95	9.3	5.7	2.4

Table 6. Effect of Fe(II) Concentration On Single Stage Leach Extraction

The low Fe(II) tenor corresponded to a slurry redox controlled at ≈+640 mV (vs Ag/AgCl) while the higher Fe(II) tenor corresponded to a slurry redox controlled at ≈+600 mV (vs Ag/AgCl). The results show similar recoveries (within expected experimental errors) for the value metals and show that low levels of Fe(II) in solution are sufficient to achieve high cobalt and manganese recoveries.

2.6.2. Effect of Acid Dose On Single Stage Leach

Three tests were completed to determine the impact of varying acid dose on leach performance. The acid doses investigated were 300, 400 and 500 kg/t. In all cases jarosite seed was added to the reactor after three hours. The SO_2 addition was controlled to target a slurry redox of ≈+600 mV (vs Ag/AgCl). The results are summarised in the Figure 10.

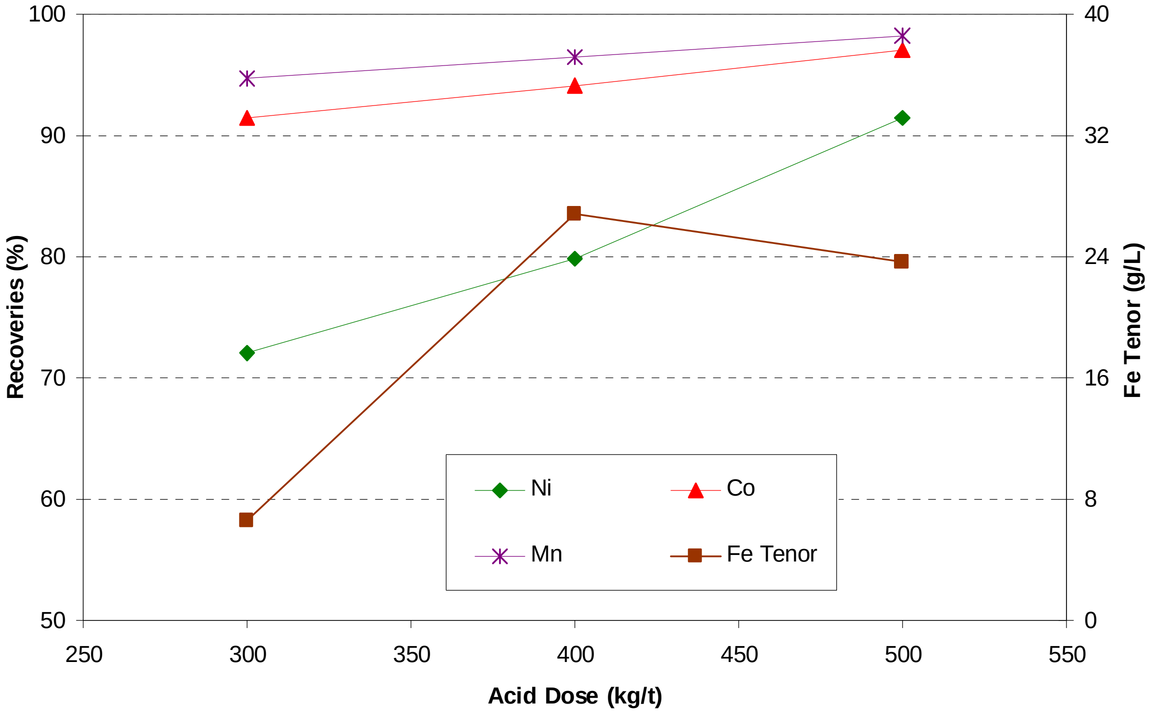

Figure 10. Effect of varying acid dose rate on leach performance

The results are very similar to those observed for the two stage leach, with cobalt and manganese recoveries increasing slightly as the acid dose increased, while nickel recoveries show a more significant increase. In addition iron rejection during the leach was similar to that observed in the split leaching testwork.

Overall the single stage leach effectively showed the same metallurgical performance as the split leach. This provided impetus to select single stage leaching as the base case flowsheet for the Mt Thirsty Project.

2.7. LEACH VARIABILITY

To validate the selection of single stage leaching and confirm the performance of the leach, ore variability testing was performed. A number of samples were identified which represented different geological zones within the deposit. The chemical analysis and resource significance of the samples selected are highlighted in Table 7.

Sample Drum	category	% of resource	Head Assay (%)								Acid Dose
			Ni	Co	Mg	Fe	Mn	Al	Cr	Si	kg/t
A	1	7	0.603	0.201	0.71	33.3	1.39	5.64	0.94	10.5	384
B	2	35	0.647	0.155	4.08	18.3	1.44	3.88	0.87	21.0	328
C	3	11	0.698	0.095	4.92	17.8	0.41	3.22	0.88	22.2	333
F	10	32	0.812	0.149	4.23	24.9	1.14	4.05	1.04	15.8	381
G	11	4	0.590	0.359	0.445	26.6	2.60	6.59	0.79	14.2	346

Table 7. Chemical Analysis Of The Samples Used For Leach Variability

Based on the previous parametric work, the following conditions were selected for the testwork, as they represented likely conditions for commercial operation. The acid consumption was varied however, to take into consideration changes in the ore's chemical composition. Therefore reaction extents at an acid dose of 375 kg acid/tonne of ore were used to model the expected acid consumption for each of the ore's tested.

- Acid Dose – Based on 375 kg acid per tonne of ore. This was varied to meet metal dissolution requirements.
- Temperature – 95^{o}C
- Leach Feed Slurry Density – 40% solids w/w
- Residence Time – 24 hours. To ensure completion of reactions. Commercial operation likely to have significantly less residence time.
- Terminal Ferrous Iron Concentration – 1-4 g/L Fe(II). Based on previous work this is equivalent to an ORP of +600 mV (vs Ag/AgCl).
- Seeding – Jarosite seed additon was added after 3 hours of leaching, as this would approximate the time of Jarosite initiation in the commercial operation.

Results are of the benchscale variability testwork are summarised in Table 8:

Sample Drum	Acid Dose kg/t	% Extraction				Liquor Assays (g/L)					Res. S Assay (%)
		Ni	Co	Mn	Fe	Ni	Al	Fe	Fe(II)	Free Acid	
A	420	82	96	96	9	4.4	12	23	1	37	7.84
B	350	85	96	98	7	4.6	12	9	1	29	4.91
C	337	85	91	94	7	4.3	9	11	4	28	5.00
F	388	81	92	96	4	6.3	11	12	7	24	6.64
G	357	85	99	99	5	3.8	10	12	5	35	7.12

Table 8. Results Of Leach Ore Variability Testwork

The results of the variability testwork are consistent with the results observed testing the composite sample used in the parametric leach testwork. Cobalt and manganese extraction varied within a reasonable range of 91-99% and 94-99% respectively.

Nickel extraction too was within a reasonable range of 81-85% resulting from terminal free acid being from 24-37 g/L. The lowest nickel extraction was observed was the 'F' sample which also had the lowest terminal free acid. This suggested more acid was required for this sample in order to achieve eqivalent nickel leach extraction.

Iron removal via jarosite precipitation was effective in all samples, with terminal iron varying between 9-23 g/L with the majority being present as ferric iron. Terminal ferrous iron concentration varied between 1-7 g/L with an ORP target of +600 mV (vs Ag/AgCl). This provided encouragement that sulphur dioxide addition could be feedback controlled to target a specifc ORP and therefore terminal ferrous iron concentration.

It should be noted the iron content of the variability samples varied between 17.8 and 33.3 % while still producing similar leach results. In the commercial operation the iron content and other acid consuming metals, such as aluminium, will be controlled by ore blending. This will ensure consistent acid addition, sulphur dioxide addition and impurity removal in downstream processing. The sulphur dioxide dose may vary throughout the life of a commercial operation as high manganese ore is likely to be treated in the early years of operation to boost overall metal production.

2.8. DOWNSTREAM PROCESSING

In addition to leaching extensive laboratory scale batch testwork was completed to observe the performance of downstream treatment. This is important to show the leach process is capable of producing a residue with good solid/liquid separation characteristics and provides a pregnant leach solution with acceptable impurities in solution. Laboratory testwork of each of the downstream processes is breifly summarised in this section of the report.

2.8.1. Intermediate Product

Within the nickel hydrometallurgical industry there are two main types of intermediate products which have commercial acceptance. These are a mixed sulphide product and a mixed hydroxide product. In the case of the Mt Thirsty Project a mixed sulphide product is more suitable for the following reasons:

1. The deposit is high in aluminium to which the the mixed hydroxide process is less tolerant
2. The deposit is high in manganese to which the mixed hydroxide process is less tolerant;
3. Manganese recovery to a manganese carbonate is maximised in the mixed sulphide process.

The process development therefore focussed on the recovery of nickel and cobalt via mixed sulphide precipitation.. In order to keep project capital costs low, the main focus of the testwork was on the use of sulphiding reagents such as sodium hydrogen sulphide and sodium sulphide. The use of these reagents rather than hydrogen sulphide gas reduces capital cost and plant complexity.

2.8.2. The Complete Mt Thirsty Simplified Flowsheet Diagram

The following complete Mt Thristy flowsheet was developed during the testwork program. A more detailed Blockflow Diagram is presented in Appendix A.

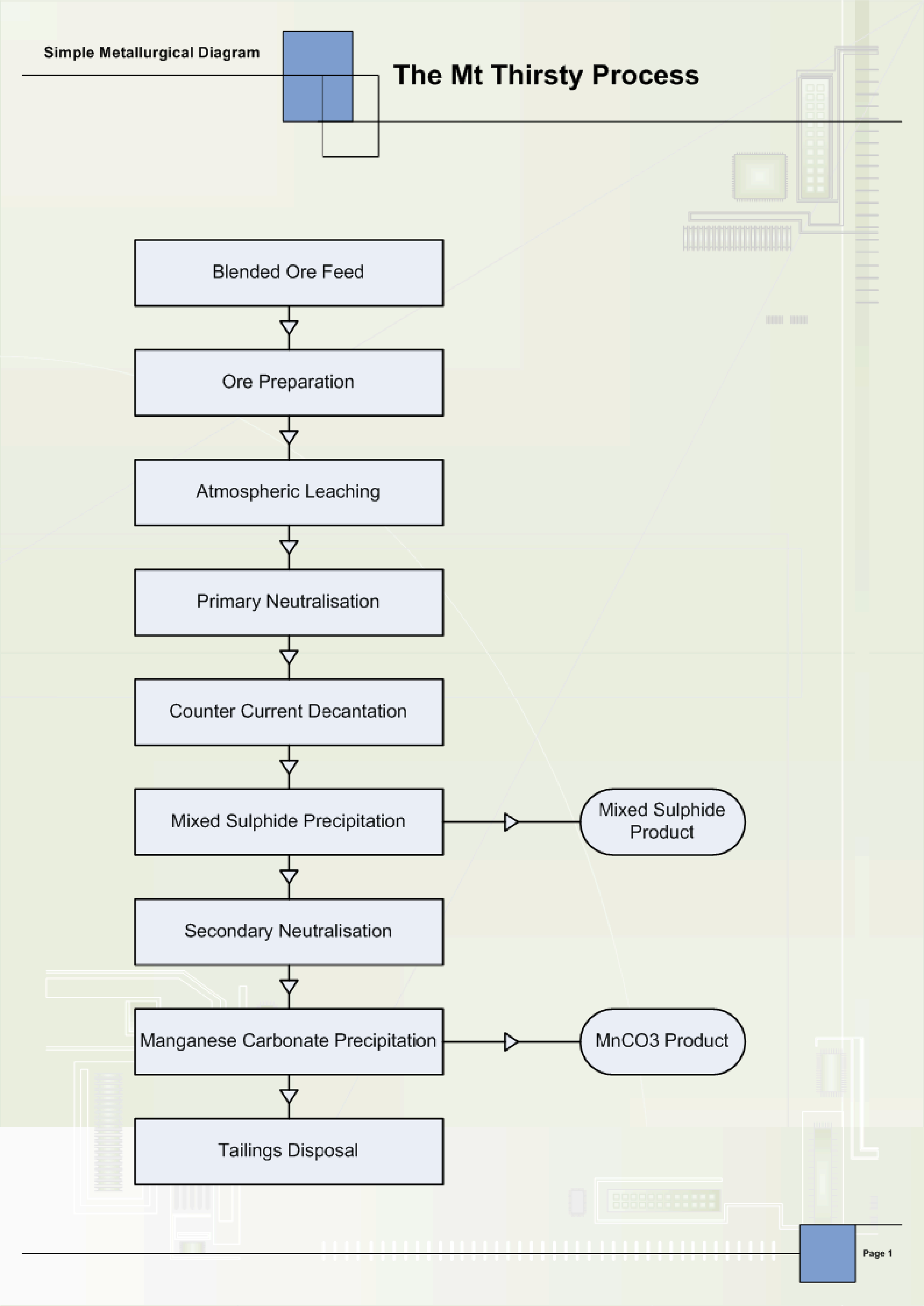

Figure 11. Simplified Mt Thirsty Metallurgical Flowsheet

2.8.3. Primary Neutralisation

Standard reactivity testwork was performed on samples of Esperance limesand to determine it's neutralising value. The acid neutralisation capacity was measured at 650 kg/tonne at a pH of 2.5.

Esperance limesand was ground to a P_{80} of 106 um and applied as a neutralisation agent to a selection of split leaching and combined leaching tests. In addition, each of the leach variability tests were neutralised with prepared Esperance limesand with good results.

Figure 12 shows the effectiveness of limesand in neutralising a typical leach discharge over a period of 60 minutes at 85°C.

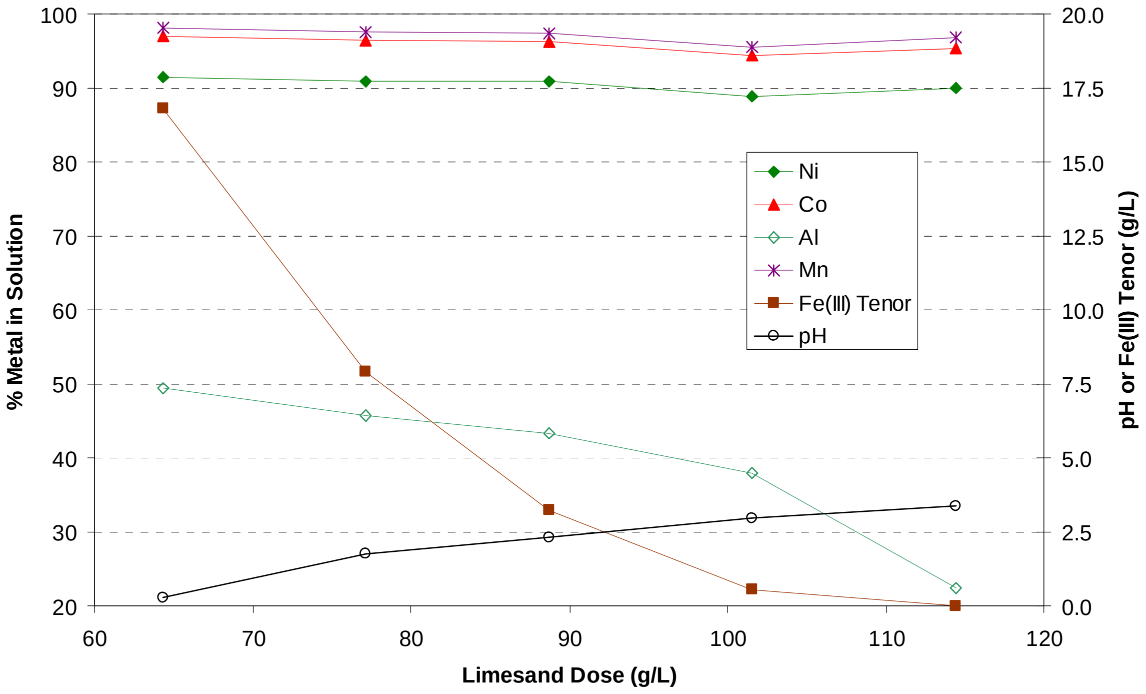

Figure 12. Primary Neutralisation Performance.

The results show the following:

- Residual acid is effectively neutralised;
- Iron is precipitated very effectively;
- Significant aluminium is also precipitated from solution;
- Minimal value metals are precipitated from solution providing selective removal of impurities.

2.8.4. Counter Current Decantation

A series of tests were performed to examine the solid/liquid separation characteristics of the leach residues produced. Overall the settling behavior was very good with high underflow densities, modest settling rates and low flocculant consumption observed. Underflow densities of greater than 50% solids are anticipated, based on rheological examination. In addition, relatively low flocculant consumtpion of 65 g/t is required to produce adequate settling. It appears the nature of the jarosite residues are favourable to solid-liquid separation.

2.8.5. Mixed Sulphide Precipitation

An extensive parametric sulphide precpitation was performed on synthetic liquors in order to determine the most effective conditions for mixed sulphide precipitation. Suitable conditons were determined to be:

- Precipitant – Sodium hydrosulphide;
- Temperature – 65 °C;
- pH – Initial pH of 2.7;
- Residence time – 6 minutes;

- Dose – 110% of Stoichiometric;
- Seeding – none performed.

A typical chemical analysis of the mixed sulphide precipitate is provided in Table 9.

Assays (% mass)								
Ni	Co	Mn	Fe	Al	Mg	Ca	Na	S
43.5	10.9	0.69	1.1	0.19	0.01	0.006	0.02	33.0

Table 9. Chemical Analysis of Typical Mixed Sulphide Precipitate

2.8.6. Secondary Neutralisation

Secondary neutralisation testwork was performed to determine the extent of selective impurity removal, prior to manganese carbonate precipitation. A range of parameters were investigated to assess the effectiveness of limesand in this duty.

The results show that near complete removal of iron and aluminium is possible with only minimal manganese precipitation of approximately 2%. Air addition and extended residence times are required to oxidise iron to a suitable valency (Fe (II) to Fe (III)) for precipitation.

The likely commercial plant conditions were determined to be:

- Temperature 60^{o}C;
- Target pH – 5.0;
- Residence time – 5 hours (batch basis);
- Seeding recycle – Likely to be 2:1, or greater.

2.8.7. Manganese Carbonate Precipitation

Manganese carbonate precipitation was investigated as a method for removing managese from solution while producing a saleable product from the precipitant. A bench scale investigative program was performed with synthetic solutions followed by a confirmatory test on solutions produced from ore leaching.

Generally the precipitation process was both effective in removing the manganese from solution and producing a high purity precipitate. Based on a near stoichiometric dose of sodium carbonate solution, the following chemical analysis was typical of the precipitates produced.

Solid Assays (% Mass)							
Ni	Co	Mn	Mg	Ca	Na	S	CO_3^{2-}
0.02	0.04	44	1.2	1.0	0.45	0.8	45

Table 10. Typical Analysis of Manganese Carbonate Product

Manganese recovery is expected to be between 80 and 90% in this stage, with the precipitates showing excellent solid-liquid separation characteristics.

3. CONCLUSION

A process for leaching nickel, cobalt and manganese from Mt Thirsty oxide ores has been developed. The process involves the steps of:

1. Providing a single leach feed slurry of oxide ore which consists of the entire ore profile;
2. Leaching the slurry with sulphuric acid;
3. Addition of reducing agents such as sulphur dioxide;

4. Controlling conditions so value metals are extensively leached from solution while impurities such as iron are precipitated from solution;
5. The process is conducted at a temperature greater than $60^{o}C$ and less than $100^{o}C$;

This development has lead to a simple leaching process which provides similar performance to that of high pressure acid leaching.

The resulting leached products are amenable to downstream treatment due to the following attributes:

- Good solid-liquid separation characteristics, which will allow for successful counter current decantation operation.
- Reduced impurities such as iron and aluminium in solution as a result of sodium ion induced precipitation.

From the pregnant leach solutions obtained, it is possible to produce a high quality mixed sulphide intermediate product. The barren solution from the mixed sulphide precipitation stage can be further purified to produce a high purity manganese carbonate product.

The Mount Thirsty Process presented in this paper will be basis for a pre-feasibility study which is targetted for completion at the end of 2010.

4. ACKNOWLEDGEMENTS

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Independent Metallurgical Operations would also like to thank Western Minerals Technology, SGS Oretest and Amdel Laboratories Perth who performed the testwork presented in this report.

5. REFERENCES

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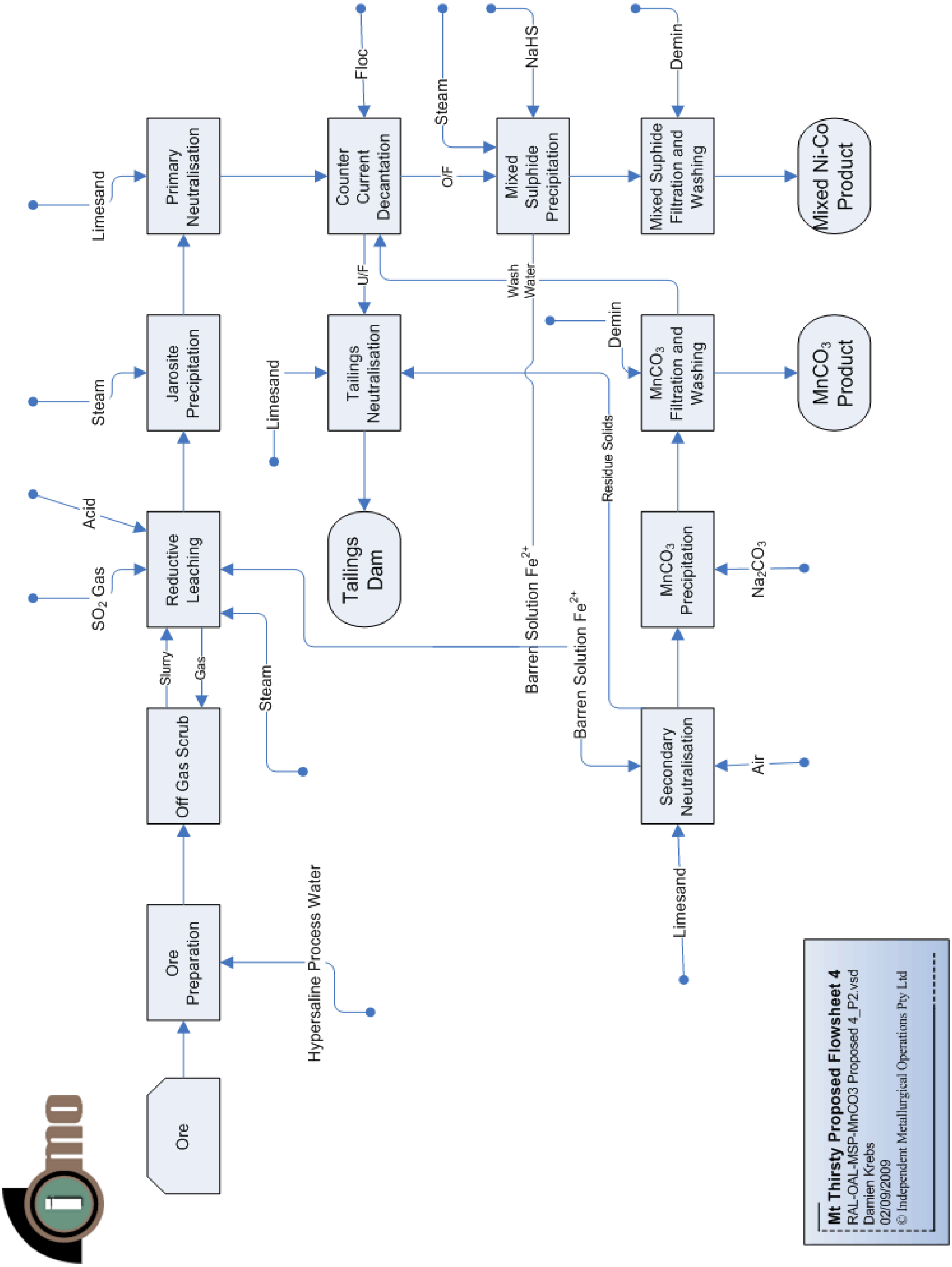
Goodwin. D., 2009, Mt Thirsty Project – Exploration Update, ASX Announcement, Barra Resources, 19 May 2009.

6. APPENDIX A


Ore
Ore Preparation
Hypersaline Process Water
Off Gas Scrub
Slurry
Gas
Steam
Reductive Leaching
SO2 Gas
Acid
Jarosite Precipitation
Steam
Primary Neutralisation
Limesand
Counter Current Decantation
Floc
U/F
Tailings Neutralisation
Limesand
Tailings Dam
O/F
Steam
Mixed Sulphide Precipitation
NaHS
Wash Water
Barren Solution Fe2+
Barren Solution Fe2+
Residue Solids
Mixed Suphide Filtration and Washing
Demin
Mixed Ni-Co Product
MnCO3 Filtration and Washing
Demin
MnCO3 Product
MnCO3 Precipitation
Na2CO3
Secondary Neutralisation
Air
Limesand
Mt Thirsty Proposed Flowsheet 4
RAL-OAL-MSP-MnCO3 Proposed 4_P2.vsd
Damien Krebs
02/09/2009
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